Highway Safety Benefit-Cost Analysis Tool: Reference Guide

FHWA Safety Program

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

http://safety.fhwa.dot.gov

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1 INTRODUCTION

The Highway Safety Benefit-Cost Analysis (BCA) Tool (the Tool) supports the implementation of the methods described and demonstrated in the Highway Safety Benefit-Cost Analysis Guide (the Guide). Specifically, the Tool provides a method for preparing a simple economic analysis of infrastructure projects, helping users to quantify projects costs as well as direct and indirect safety-related benefits of project alternatives. Direct safety benefits include the expected change in crash frequency and severity. Indirect benefits include the operational and environmental benefits that result from a reduction in crashes (i.e., reduced travel time, improved travel time reliability, reduced fuel use, and reduced emissions).

Given certain input data for a project, the model calculates the present value costs, present value benefits, net present value, and benefit-cost ratio. The benefits are derived from the estimated change in crashes between the base condition and an alternative scenario. While the user has multiple options for estimating and entering safety benefits in the Tool, the benefits are based on changes in crashes by severity. The Tool does not estimate benefits by crash type or by combinations of crash type and severity. Further, the crash severity levels are defined by the five-level KABCO scale; however, there is a conversion process if an agency estimates the change in crashes by different severity levels.

The Tool is intended for project-level analysis of single or multiple improvements at a given location. It can also support network-level economic analysis for projects that include multiple locations (e.g., systemic improvements). It does not address behavioral measures, or the direct benefits related to operations and the environment (i.e., those benefits not derived from a change in safety performance). Agencies may use other tools to quantify the benefits of behavioral measures and non-safety factors (e.g., microsimulation to estimate operational impacts; noise and emissions models to estimate environmental impacts).

While the Guide and Tool provide methods and default values to monetize the direct and indirect safety benefits of alternatives, a BCA is a policy or procedural decision where an agency defines the parameters. Agencies should develop a prioritization process that meets their specific needs, integrating quantitative safety and non-safety factors as needed.

2 OVERVIEW OF THE TOOL

The Tool is a basic spreadsheet application with two primary worksheets for inputting data, a worksheet summarizing the analysis parameters, a worksheet summarizing results, and several worksheets that perform and present background computations. Table 1 provides a summary of the worksheets in the BCA Tool.

Table 1. Highway Safety BCA Tool worksheet summary.

Worksheet	Description
Home Page	Provides a navigation menu, links to additional guidance documentation and contact information.
Instructions	Provides instructions for using the Tool.
1) Project Information	Analyst-supplied data used to estimate project costs and benefits.
2) Project Crash Data	Analyst-supplied data and calculations used to estimate annual crash reductions.
3) Analysis Parameters	Parameters used for benefit calculations.
4) Results	Summary of analysis results.
Crash Benefits	Calculates the monetary benefit for annual crash reductions resulting from a reduction in crash frequency and severity.
Travel Time Benefits	Calculates the monetary benefit for annual reductions in travel time delay resulting from a reduction in crash frequency and severity.
Reliability Benefits	Calculates the monetary benefit for annual improvements to travel time reliability resulting from a reduction in crash frequency and severity.
Vehicle Operating Cost Benefits	Calculates the monetary benefit for the annual reduction in vehicle operating costs resulting from a reduction in crash frequency and severity.
Emissions Benefits	Calculates the monetary benefit for the annual reduction in emissions resulting from a reduction in crash frequency and severity.
Lookup	Reference tables used to calculate project benefits.
Final Calculations	Calculations for the present value of project costs and benefits.

The Home Page is a useful reference point to navigate worksheets in the Tool using simple hyperlink buttons shown in Figure 1.

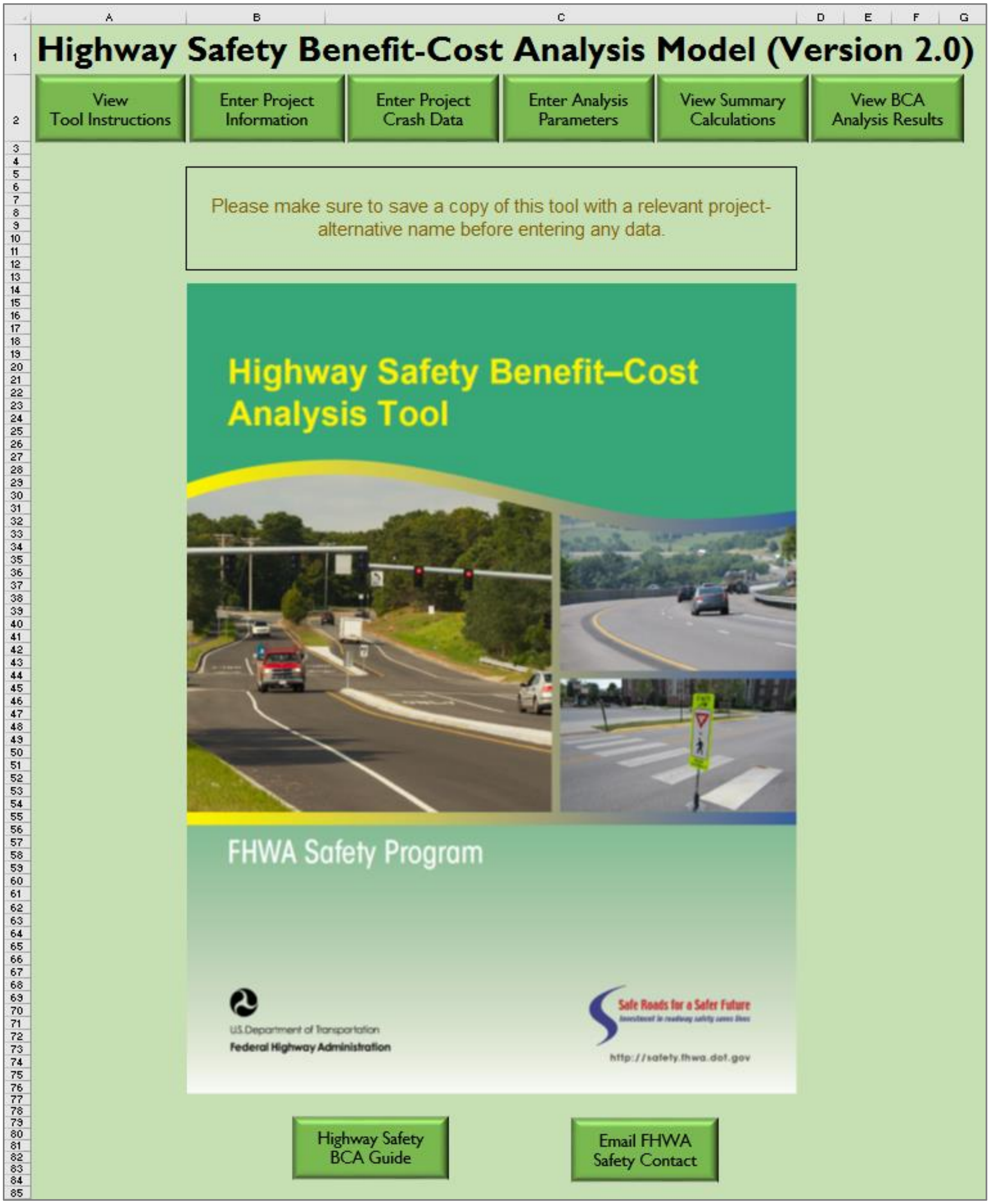


Figure 1. Screenshot. Hyperlink menu in the Home Page worksheet.

3 INSTRUCTIONS

Analysts may complete a BCA simply by entering a limited amount of data on the Project Information and Crash Information worksheets. Analysts may view the results on the Results worksheet. The Analysis Parameters worksheet allows the analyst to review and adjust the parameters used to calculate project benefits, such as value of time, travel time delay factors, vehicle operating cost factors, and emissions factors.

The model also provides a set of worksheets that calculate benefits for crashes, travel time, reliability, vehicle operating costs, and emissions. These worksheets are described in further detail in Section 4 of this reference guide. These worksheets perform calculations automatically and no analyst input is needed or recommended. All data and calculations in the Tool are transparent and reviewable by the user. All cells in the worksheets that do not require or allow user input are protected from accidental modification. However, users may update and modify the Tool as they see fit. The Tool password for all protected cells and sheets is safety, all lower case.

3.1 Cell Color Codes

Cells are color-coded to assist analysts in the data entry and calculation process. Figure 2 summarizes the color codes.

Cell Type	Color Coding	Description
Analyst-Supplied Data	0.00	Cell allows data input from the analyst.
Model Default	0.00	Default value provided in the model. Defaults may be modified by the analyst using adjacent green cells. A green cell overrides its adjacent blue default cell in all calculations.
Model Parameter	0.00	Model parameter provided in the model based on the selection of roadway type. No analyst input is needed; however, these values can be modified using adjacent green cells.
Model Calculation	0.00	Model calculation based on parameters and linked cells. No analyst input is required.
Linked Cell	0.00	A cell value linked to another worksheet in the Tool. No analyst input is required.

Figure 2. Chart. Cell color codes.

3.2 Project Information Worksheet

Analysts begin the data entry process by entering the following basic project information, which is used to identify the analysis presented on the results worksheet:

- **Agency**: The name of the transportation agency conducting the BCA.
- **Project Title**: The title of the project.
- **Date**: The date of the analysis.
- **Analyst**: The name of the analyst conducting the BCA.
- **Build Alternative Name**: The name of the build alternative analyzed in the BCA.

The model requires analyst-supplied data to estimate project costs and benefits. The Project Information worksheet has two main components, which require analyst-supplied data and information: 1) project data and 2) project costs. The following sections describe the required inputs for these two components.

3.2.1 Project Data

Analysts must provide several pieces of information in the Project Data section. The selections made on this worksheet are critical to all other calculations completed inside the model. There are two levels of inputs depending on the desired outputs and benefits included in the BCA. Table 2 summarizes the required inputs for the analysis of benefits related to a reduction in crashes and the resulting benefits to travel time, vehicle operating costs, and emissions. Refer to the Guide for further discussion of inputs such as the analysis period.

Table 2. Analyst-supplied inputs for general benefits in the project data section.

Item	Description
Roadway Facility Type	Analyst-supplied information for roadway facility type with five choices: • Urban Interstate/Expressway • Urban Arterial • Urban Other • Rural Interstate/Principal Arterial • Rural Other
Analysis Period (Years)	The length of the analysis period in years. This input is used to calculate benefits and costs over the appropriate time period specified by the analyst. This value should be the same for each alternative.
Length of Construction Period (Years)	The expected duration of construction in years.

Table 3 summarizes the Tool-supplied defaults for the analysis of benefits related to a reduction in crashes and the resulting benefits to travel time, vehicle operating costs, and emissions. The user can modify these values using the adjacent green cells. Refer to the Guide for further discussion of inputs such as the discount rate, fuel cost, and value of time.

Table 3. Tool-supplied defaults for the project data section.

Item	Description
Total Time Period (Years)	Calculated total of the analysis period plus the construction period.
Discount Rate (Percent)	The discount rate used to calculate benefits and costs over the analysis period. The default is 3 percent.
Percent of Trucks in the Flow	Defaults for percent trucks are provided for each facility type in the model. These can be modified by the user. This assumption is used to calculate the average value of time for the facility under study.
Fuel Cost ($ Dollars)	The per-gallon fuel cost used to calculate vehicle operating costs. Standard values may be obtained from the Bureau of Transportation Statistics.
Value of Time ($/Hr.) Personal	Used to value time savings from higher speeds, improved clearance, and improved reliability for Passenger vehicles.
Value of Time ($/Hr.) Freight	Used to value time savings from higher speeds, improved clearance, and improved reliability for Freight vehicles.
Calculated Combined Value of Time	Average value of time, weighted by the percent trucks and percent auto in the flow.

If the analyst would like to include reliability benefits in the BCA, then additional information is required. Table 4 summarizes the required inputs for the analysis of reliability benefits related to a reduction in crashes. Refer to the Guide for further discussion of inputs such as the reliability ratio.

Table 4. Analyst-supplied inputs for reliability benefits in the project data section.

Item	Description
Segment Length (Miles)	Length of segment where the travel time reliability is impacted by the project under review. Segments can be of any length, but it is recommended that they not be so long that the characteristics change dramatically along the segment, or too short that input is burdensome. The following are examples of reasonable segment lengths: • Restricted access roadways (e.g., freeways and interstates): define the analysis section between two or more interchanges. • Signalized arterial corridors: define the analysis section between two or more signals. • Rural highways (non-freeways): define the analysis section in 2- to 5-mile segments.
Number of Lanes	Lanes in one direction for freeway and arterials. Both directions for rural two-lane roads.
Free Flow Speed (MPH)	Based on facility type or observation.
Traffic Volume (during peak period)	Based on vehicle counts during peak period in vehicles per hour per mile for all lanes as specified above.
Link Capacity	Based on Highway Capacity Manual methods, calculated by the Tool or overridden by user.
Hours of Peak Traffic per Day	Indicates the number of peak hours to consider in the analysis. This can be by AM/PM peak or for the full day.
Days of Analysis per Year	This is used in reliability benefit calculations, usually the number of commute days analyzed. The default is 260 days, but can be overridden by user.
Reliability Ratio Personal	The ratio of value of time saved on a trip to the value of time saved from improved reliability for passenger vehicles.
Reliability Ratio Freight	The ratio of value of time saved on a trip to the value of time saved from improved reliability for freight vehicles.

3.2.2 Project Costs

The analyst must enter a complete set of project construction costs in the table provided in this section of the worksheet. The analyst must enter the data for each year in the analysis period and include all calculated life-cycle costs in the appropriate year, including initial costs, maintenance and operations costs, and major rehabilitation costs. Table 5 summarizes the required inputs for the analysis. The Guide describes project costs in further detail in chapter 3.

Table 5. Project cost items summary – project information worksheet.

Item	Timeframe	Description
Project Support	Construction	Costs associated with planning, preliminary engineering, and final engineering.
Right-of-Way	Construction	Costs associated with right-of-way acquisition.
Construction	Construction	Costs associated with construction of the build alternative.
Maintenance and Operations	Project Open for Traffic	Continuing costs associated with maintenance and operations of the alternative including: • Labor for maintenance and operations. • Materials and equipment for maintenance and operations. • Utilities costs. • Rent and lease payments. • Emergency repairs.
Rehabilitation	Project Open for Traffic	Future cost of repairs beyond routine maintenance including those incurred at the end of a project or period of analysis.
Mitigation	Construction and Project Open for Traffic	Costs associated with mitigating environmental impacts during construction and at project open.

3.3 Crash Information Worksheet

The Crash Information worksheet is critical to the calculation of benefits used in the model. The calculation for annual reductions in crash frequency and severity is the primary input to the rest of the calculations conducted in the BCA. The worksheet requires data for the estimated annual crashes without treatment and the appropriate crash modification factor (CMF) to be used in the analysis.

Safety benefits are the expected change in crash frequency associated with a project alternative relative to the base condition. In general, there is a need to estimate the safety performance of the base condition, then estimate the safety performance of the alternative condition, and finally take the difference to determine the change in safety. One option for estimating the change in safety is to apply CMFs to the long-term average safety performance for the base condition. When relevant CMFs are not available, it may be appropriate to estimate the change in safety performance by comparing the predicted crashes from one or more SPFs. For example, CMFs do not exist for a project that would convert a rural, two-lane, undivided highway to a rural, multilane, undivided highway; however, the Highway Safety Manual Part C Predictive Method provides SPFs and corresponding adjustment factors to estimate the safety performance of these two conditions.

The Tool facilitates these options on the 'Project Crash Data' worksheet. If you have already estimated the expected change in crashes by severity, then enter this information as an override value for each severity level in the green cell next to the CMF estimated crash reductions. The Tool will then use these values for all benefit calculations. If you prefer to estimate the annual crashes for the base condition and apply a CMF to estimate the change in crashes, then proceed as follows:

1. Select single or multiple countermeasures from the dropdown box as shown in Figure 3. This worksheet allows the analyst to estimate crash reductions where a single or multiple (two) countermeasure(s) are deployed.
2. If multiple countermeasures, select the appropriate calculation method to estimate the combined effect from the dropdown box as shown in Figure 3. There are four options for methods to estimate the combined effect of multiple countermeasures: dominant effect, additive, multiplicative, and dominant common residuals. Refer to section 6.1 of the Guide for further guidance on how to select an appropriate method to estimate the combined effect of multiple countermeasures.

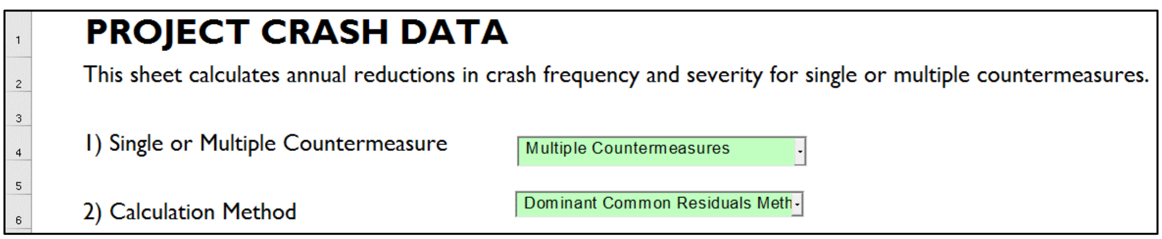


Figure 3. Screenshot. Number of countermeasures and calculation method.

3. Enter values for the *estimated annual crashes without treatment* (i.e., the base condition) as shown in Figure 4. The Tool does not provide the functionality to estimate crash frequency and severity for the base condition. Instead, the analyst must develop these estimates outside of the Tool, using methods such as those presented in the Highway Safety Manual. Refer to chapter 5 of the Guide for further discussion of how to establish the base condition and estimate the annual crashes without treatment. Further, the Tool does not explicitly account for traffic growth. As such, the input for the estimated annual crashes without treatment should represent the average annual crashes over the

analysis period. If traffic volume is expected to change during the analysis period, then consider using the average traffic volume over the analysis period when using predictive methods to estimate the average annual crashes.

4. Enter values for *CMF1* (and *CMF2* as appropriate) as shown in Figure 4. The analyst must obtain an applicable CMF value from another source such as the CMF Clearinghouse (The Tool provides a hyperlink button to the Clearinghouse). It is important to select and apply high-quality and applicable CMFs when possible. The Tool and Guide assume users are familiar with the selection of applicable CMFs. Refer to the CMF Clearinghouse for further guidance and resources on identifying and selecting CMFs. Refer to section 6.1 of the Guide for further guidance on applying CMFs to estimate safety benefits.

BASELINE CRASH DATA AND CRASH MODIFICATION FACTORS

Enter estimated annual crashes without treatment and Crash Modification Factors (CMF).

CMF Clearinghouse

Injury Severity Scale	Estimated Annual Crashes without Treatment	CMF1	CMF2
K	0.05	0.72	0.96
A	0.92	0.72	0.96
B	2.89	0.72	0.96
C	3.67	0.72	0.96
O	8.92	0.83	0.96

Figure 4. Screenshot. Baseline crash data and CMF input.

Figure 5 shows the section with calculations for the annual reduction in crash frequency by severity. If the user enters values in the *User Determined Reduction in Crashes*, then the values in those green cells will be used in all benefit calculations.

CALCULATION FOR THE ANNUAL REDUCTION IN CRASH FREQUENCY AND SEVERITY

This section automatically calculates annual reduction in crash frequency and severity. No user input is required for this table. However if the user wishes to override or enter externally calculated Crash Reductions, they may be entered in the Green cells, Column (5).

Formula 1: Estimated Annual Reductions with Treatment (3) = (1) Estimated Crashes without Treatment x (2) Crash Modfication Factor

Formula 2: Annual Reduction in Crashes (4) = (3) Estimated Annual Reduction with Treatment - (1) Estimated Crashes without Treatment

Injury Severity Scale	(1) Estimated Annual Crashes without Treatment	(2) Crash Modification Factor	(3) Estimated Annual Crashes with Treatment	(4) Annual Reduction in Crashes	(5) User Determined Reduction in Crashes
K	0.05	0.86	0.04	**0.01**	
A	0.30	0.66	0.20	**0.10**	
B	0.80	0.66	0.53	**0.27**	
C	1.20	0.50	0.60	**0.60**	
O	2.60	0.45	1.17	**1.43**	
Total	4.95		2.54	2.41	

Figure 5. Screenshot. Calculation of annual change in crash frequency by severity.

3.4 Analysis Parameters Worksheet

The 'Analysis Parameters' worksheet contains the parameters used for benefit calculations. This worksheet is linked to the tables in the 'Lookup' worksheet. No analyst input is required for this worksheet; however, the analyst may override the model-supplied parameters by inputting values in the green cells as shown in Figure 6.

Roadway Facility Type	Urban Other	
	Parameter	**User Defined**
Value of Time	26.58	
Travel Time Delay Factors	**(Hours/Crash)**	
Fatal	207.88	0.00
Injury	15.40	0.00
PDO	10.32	0.00
Vehicle Operation Cost Factors	**(Gallons/Crash)**	
Fatal	39.00	0.00
Injury	17.00	0.00
PDO	10.00	0.00

Color Codes

User-Supplied Data	
Model Parameter	

Users may modify default values by entering user defined values in the green cells on the right of the Lookup entry.

Next Step

Emissions Factors (Dollars/Crash)	CO2	CO	NOx	PM10	PM2.5	SO2	VOC
Fatal	$16.37	$0.00	$3.95	$0.00	$8.92	$1.41	$0.27
Injury	$7.18	$0.00	$1.72	$0.00	$3.76	$0.62	$0.12
PDO	$4.33	$0.00	$1.05	$0.00	$2.25	$0.36	$0.08

Figure 6. Screenshot. Analysis parameters worksheet.

3.5 Results Worksheet

The 'Results' worksheet provides a summary of analysis results as shown in Figure 7. The summary output is formatted to cleanly fit on an 8.5- by 11-inch sheet. This worksheet is provided to summarize the BCA results and no analyst input or modification is needed or recommended.

Case 1, Alternative 2

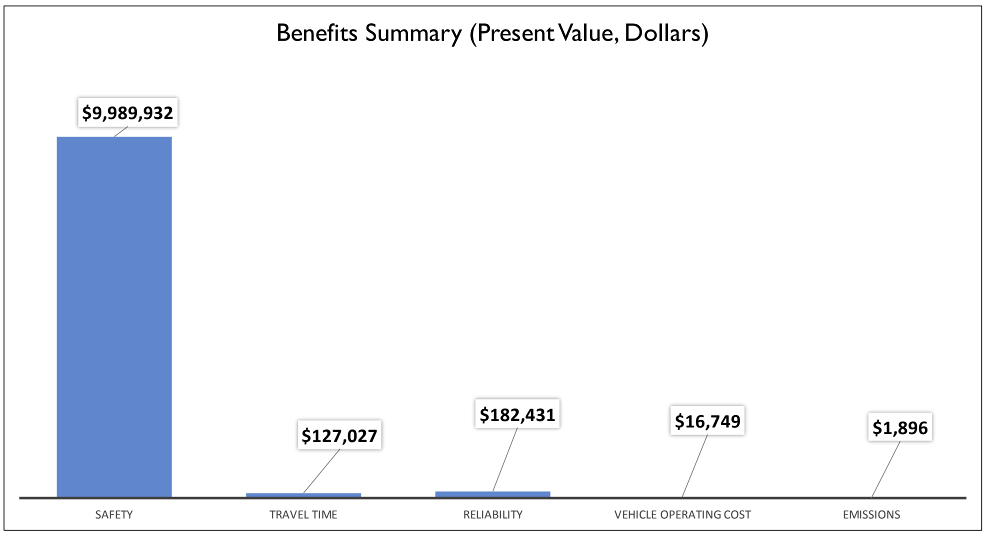
Benefit-Cost Analysis Summary Results

Print

AGENCY: DOT **DATE** 2/14/2018

Present Value Costs ($ Dollars)	$900,000
Present Value Benefits ($ Dollar	$10,318,036
Net Present Value ($ Dollars)	$9,418,036
Benefit / Cost Ratio:	11.46
Discount Rate	3.0%

ITEMIZED BENEFITS ($ Dollars)	Present Value
Safety	$9,989,932
Travel Time	$127,027
Reliability	$182,431
Vehicle Operating Cost	$16,749
Emissions	$1,896
TOTAL BENEFITS	**$10,318,036**



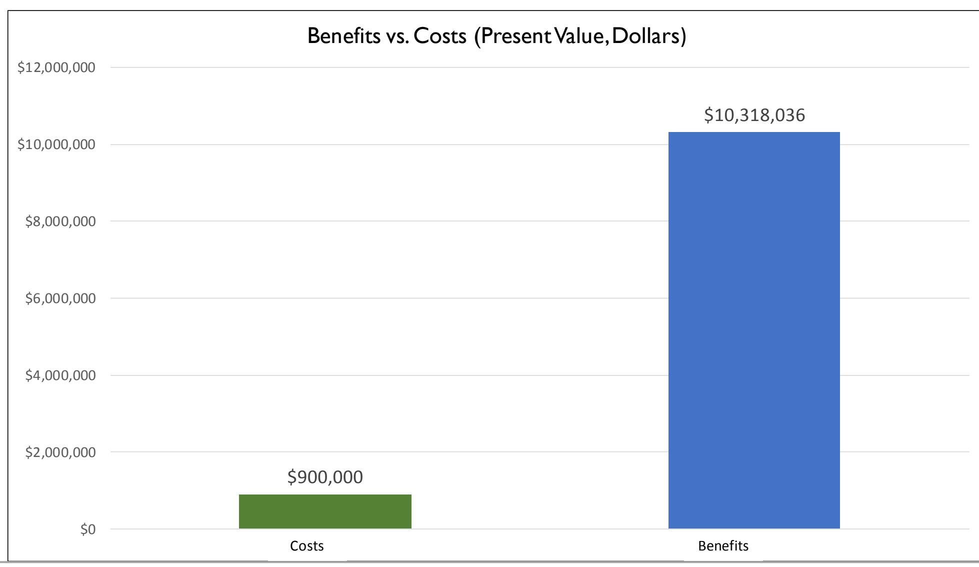


Figure 7. Screenshot. Example results worksheet.

3.6 Lookup Worksheet

The 'Lookup' worksheet contains reference tables used to calculate project benefits. The data tables provided on this worksheet are for reference purposes and no analyst input or modification is needed or recommended.

3.7 Final Calculations Worksheet

The 'Final Calculations' worksheet calculates the present value of project costs and benefits. The calculations from this worksheet are then linked to the 'Results' worksheet. Calculations on this worksheet occur automatically and no analyst input is needed or recommended.

4 BENEFITS WORKSHEETS

The Tool contains five worksheets used to calculate the monetary benefit associated with the annual estimated change in crashes, and the resulting change in travel time, reliability, vehicle operating costs, and emissions. This section briefly describes the calculation process and parameters used in the worksheets. The calculations in these worksheets are generally intended for review purposes. The Tool is organized so the benefits calculations are completed automatically with no input required by the analyst beyond the project information already provided. The methods used to calculate project benefits are further described in chapter 4 and chapter 6 of the Guide.

The annual benefit estimates calculated in these sheets are linked to the 'Final Calculations' worksheet, where the present value benefits are computed over the analysis period using an amortization table.

4.1 Crash Benefits

The 'Crash Benefits' worksheet calculates the monetary benefit for annual crash reductions. The calculation includes the annual reduction in crashes and the comprehensive crash unit cost by crash severity level. These two values are multiplied to estimate the annual monetary benefit.

A BCA is a policy or procedural decision where an agency defines the parameters, including the crash costs used for economic analysis. Agencies establish crash costs using different methods based on internal policy decisions. It is important to use the crash costs established for the agency or program to which the project applies. Further, given that agencies often prioritize projects using the BCR, it is important to use consistent crash costs within an agency.

The Crash Costs for Highway Safety Analysis guide proposes a set of national crash unit costs and procedures to 1) update the crash unit costs over time, and 2) adjust the crash unit costs to States based on State-specific cost of living, injury-to-crash ratios, and vehicle-to-crash ratio. The Tool and Guide use the national crash costs as defaults, but the user should override these values with agency- or program-specific crash costs when available. If an agency does not have established values for crash unit costs, then analysts can use the default values provided in the Tool and Guide or input crash cost values from another source.

Users can modify or update the crash cost defaults from the 'Lookup' worksheet. To do so, the user would unprotect the sheet (using the password 'safety') and replace the current crash cost values. This would change the crash costs in all uses within the Tool.

Calculations on this worksheet occur automatically and no analyst input is required. Refer to chapter 4 and chapter 6 of the Guide for additional information on the calculation of crash benefits.

4.2 Travel Time Benefits

The 'Travel Time Benefits' worksheet calculates the monetary benefit for the annual reduction in travel time delay based on the annual reduction in crashes. The National Highway Traffic Safety Administration (NHTSA) completed a study in 2010[1], later revised in 2015, which evaluated and monetized the economic and societal impact of motor vehicle crashes. NHTSA developed the most recent research on the fiscal impact of motor vehicle crashes, including aggregate increases in air emissions, vehicle operating costs, and travel time that result from specific crashes. For travel time, NHTSA estimated the total delay experienced for fatal, injury, and PDO crashes for five different types of roadway facilities:

- Urban Interstates/Expressways.
- Urban Arterials.
- Urban Other.
- Rural Interstates/Principal Arterials.
- Rural Other.

The NHTSA approach is particularly useful for monetizing the average delay hours per crash by crash severity and roadway facility type. Tables in the 'Lookup' worksheet provide the values developed by NHTSA to estimate travel time delay, which are transferred to the 'Analysis Parameters' worksheet based on the user-selected facility type. The user can override the default values on the 'Analysis Parameters' worksheet if desired. Calculations in 'Travel Time Benefits' worksheet occur automatically and no analyst input is required. Refer to chapter 4 and chapter 6 of the Guide for additional information on the calculation of travel time benefits.

[1] National Highway Traffic Safety Administration, *The Economic and Societal Impact Of Motor Vehicle Crashes, 2010 (Revised)*, May 2015, Accessed at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013

4.3 Reliability Benefits

The 'Reliability Benefits' worksheet calculates the monetary benefit for the annual improvements to reliability based on the annual reduction in crashes. The Second Strategic Highway Research Program (SHRP2) developed the SHRP2 C-11 Reliability Module, which is a spreadsheet tool to assess impacts on travel time reliability. The Reliability Module involves minimal data development and model calibration. The tool simplifies the analysis process for the transportation professional, who may not necessarily possess traffic engineering expertise. The procedure in the Reliability Module is based on the results of other SHRP2 projects, estimating recurring and nonrecurring congestion, and using predictive equations to develop reliability metrics.

The 'Reliability Benefits' worksheet incorporates the methods from the SHRP2 reliability research. The data needed for these calculations are found on the 'Project Information' worksheet as defaults or as user provided data. Calculations on this worksheet occur automatically and no analyst input is required. Refer to chapter 4 and chapter 6 of the Guide for additional information on the calculation of reliability benefits.

4.4 Vehicle Operating Costs Benefits

The 'Vehicle Operating Costs Benefits' worksheet calculates the monetary benefit for the annual reduction in vehicle operating costs based on the annual reduction in crashes. The NHTSA approach, described above in section 4.2, Travel Time Benefits, is useful for monetizing fuel-related vehicle operating cost reductions by crash severity and roadway facility type. Tables in the 'Lookup' worksheet provide the NHTSA-developed vehicle operating cost factors, which are transferred to the 'Analysis Parameters' worksheet based on the user-selected facility type. The user can override the default values on the 'Analysis Parameters' worksheet if desired. Calculations on the 'Vehicle Operating Costs Benefits' worksheet occur automatically and no analyst input is required. Refer to chapter 4 and chapter 6 of the Guide for additional information on the calculation of vehicle operating cost benefits.

4.5 Emissions Benefits

The 'Emissions Benefits' worksheet calculates the monetary benefit for the annual reduction in emissions. The NHTSA approach, described above in section 4.2, Travel Time Benefits, is useful for monetizing emissions reductions by crash severity and roadway facility type. Tables in the 'Lookup' worksheet provide the NHTSA-developed emissions factors, which are transferred to the 'Analysis Parameters' worksheet based on the user-selected facility type. Calculations on this worksheet occur automatically and no analyst input is required. Refer to chapter 4 and chapter 6 of the Guide for additional information on the calculation of emissions benefits.

5 EVALUATING SYSTEMIC COUNTERMEASURE PROGRAMS

Safety BCA is designed to provide a simple platform for assessing and comparing project-level alternatives. In some cases, the analyst may wish to evaluate multiple deployments of a single countermeasure over multiple sites or a region (e.g., systemic improvements).

Safety BCA can assist with the process of evaluating and prioritizing locations for systemic improvements. For example, consider a scenario where an agency is developing a systemic sign package to address curve-related crashes along rural, two-lane roads. The agency has identified curve-related fatal and serious injury crashes as the focus crash type, and rural, two-lane local roads as the focus facility type. Based on further analysis of these crashes, the agency selected a low-cost signing improvement to warn drivers of the curves; however, the agency only has $5,000 for the curve signing project and would like to identify the most effective use of funds. To select sites for the systemic sign project, the agency would estimate the BCR for each curve and then rank the sites by BCR from high to low. The sites with the highest BCR values would receive the sign package until funds are exhausted.

This type of analysis requires multiple runs of the Tool. For example, if there are 10 potential curves in the systemic sign improvement scenario above, then the analyst would run the Tool 10 times, once for each site. The BCA of each potential site may be unique due to the specific characteristics for each deployment. To assist in this process, there is a Multipack10 download that serves as a companion to the Tool. This download consists of ten copies of the Tool and a Summary file that collects the 'Results' pages from each of the ten models.

Figure 8 displays the Multipack10 file structure based on data from the example in section 7.4 of the Guide. The user can rename these files for convenience. To run the Multipack10, simply open the Safety BCA Results Summary file. This pulls the information from the other 10 files in the folder.

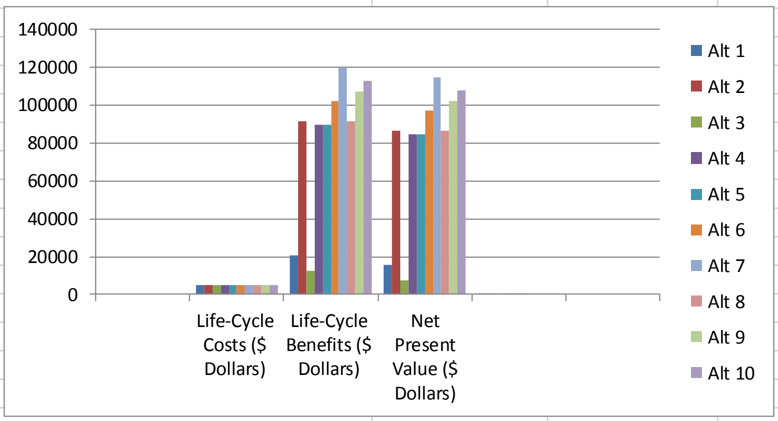
Name	Type	Size
Safety BCA Results Summary - MP 10 Ch7 Case 4 Curve All 10	Microsoft Excel Macro-Enabled Worksheet	270 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 1 V 2.0	Microsoft Excel Macro-Enabled Worksheet	619 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 2 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 3 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 4 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 5 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 6 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 7 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 8 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 9 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB
SafetyBCA Tool MP10 Ch7 Case 4 Curve 10 V 2.0	Microsoft Excel Macro-Enabled Worksheet	618 KB

Figure 8. Screenshot. Multipack10 file structure.

The user can create a Multipack of any size with some simple Excel development work. For example, if there were twenty deployments planned, the user could run two Multipack10 folders and then combine the two Summary files into one. As another option, the user could first create a multipack file by copying the Safety BCA file the number of times required. Then, the user would create a summary file by copying and moving the "Results" page from each file to the Summary file. Finally, the user would create a Summary sheet within the Summary file where the data of interest is pulled from each of the results sheets. Figure 9 provides an example of a Multipack10 Summary Page to compare the 10 results side by side. Note all ten cases are shown on the full Summary sheet.

	Alt 1	Alt 2	Alt 3
Life-Cycle Costs ($ Dollars)	$ 5,000	$ 5,000	$ 5,000
Life-Cycle Benefits ($ Dollars)	$ 20,670	$ 91,327	$ 12,396
Net Present Value ($ Dollars)	$ 15,670	$ 86,327	$ 7,396
Benefit / Cost Ratio:	4.13	18.27	2.48

ITEMIZED BENEFITS (2017 Dollars)	Alt 1	Alt 2	Alt 3
Crash Cost Savings	$ 20,541	$ 91,159	$ 12,315
Travel Time Savings	$ 121	$ 157	$ 75
Travel Time Reliability	$ -	$ -	$ -
VOC Cost Savings	$ 8	$ 10	$ 5
Emission Cost Savings	$ 0	$ 0	$ 0
TOTAL BENEFITS	$ 20,541	$ 91,327	$ 12,396



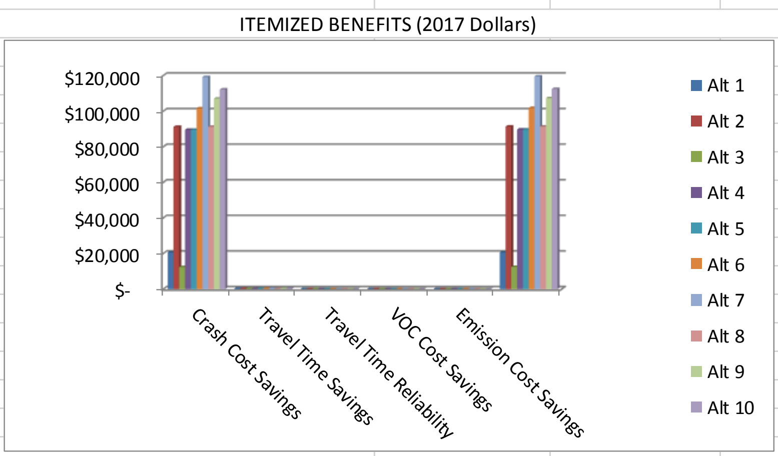


Figure 9. Screenshot. Multipack10 summary sheet (partial).

6 SUMMARY

The Tool supports the implementation of the Highway Safety Benefit-Cost Analysis Guide. Given basic input data for a project, the model calculates the present value costs, present value benefits, net present value, and benefit-cost ratio. The benefits are derived from the estimated change in crashes between the base condition and an alternative scenario. While it includes travel time, reliability, vehicle operating costs, and emissions benefits that result from a reduction in crashes, it does not include the direct benefits related to operations and the environment (i.e., those benefits not derived from a change in safety performance).

The Tool is intended for project-level analysis of single or multiple improvements at a given location. It can also support network-level economic analysis for projects that include multiple locations (e.g., systemic improvements).

While the Tool provides default values to monetize the direct and indirect safety benefits of alternatives, a BCA is a policy or procedural decision where an agency defines the parameters. Agencies should customize the Tool to meet their specific needs, overriding the default values as needed, particularly the crash costs. Refer to the Guide for further discussion of the default values and methods included in the Tool.

For More Information:

Visit https://safety.fhwa.dot.gov/

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